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(71) Applicant (*for all designated States except US*): **ENVENTURE GLOBAL TECHNOLOGY** [US/US]; 16200-A Park Row, Houston, TX 77084 (US).

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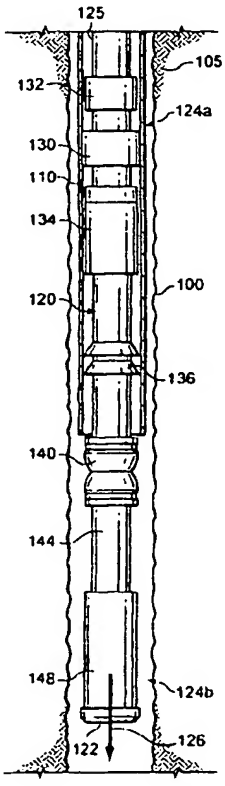
(74) Agents: **MATTINGLY, Todd** et al.; Haynes and Boone, LLP, Suite 4300, 1000 Louisiana Street, Houston, TX 77002-5012 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[Continued on next page]

(54) Title: MONO DIAMETER WELLBORE CASING



(57) Abstract: An apparatus (120) and system for radially expanding and plastically deforming an expandable tubular member (110) where the system comprises an anchoring mechanism (148) adapted to mate with an end of the expandable tubular member (110), a tubular member (125) releasable coupled to the anchoring mechanism (148) \, an adjustable expansion mandrel (140), and an actuator (134) coupled to the adjustable expansion mandrel (140) to controllably longitudinally displace the adjustable expansion mandrel (140) relative to the expandable tubular member (110). The expansion mandrel (140) is controllably expanded to a larger diameter for radial expansion of the expandable tubular mandrel (110) or collapsed to a smaller outside diameter.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/14153

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : E21B 29/00
US CL : 166/384
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/277,381,382,384,386,387,297,55,206,207,212,216,217,242.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,012,523 A (Campbell et al.) 11 January 2000 (11.01.2000), columns 3 and 4.	1-3,7-12
Y	US 4,848,459 A (Blackwell et al.) 18 July 1989 (18.07.1989), see Figure 1.	1-3,7-12
A	US 6,112,818 A (Campbell et la.) 05 September 2000 (05.09.2000), see Abstract.	1-12
A, P	US 6,425,444 B1 (Metcalfe et al.) 30 July 2002 (30.07.2002), see Abstract.	1-12
A, P	US 6,631,765 B2 (Baugh et al.) 14 October 2003 (14.10.2003), see Abstract.	1-12
A	US 3,785,193 A (Kinley et al.) 15 January 1974 (15.01.1974), see Abstract.	1-12
A	US 6,021,850 A (Wood et al.) 08 February 2000 (08.02.2000), see Abstract.	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

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Continuation of B. FIELDS SEARCHED Item 3:
EAST
search terms: expand, anchor, packer, valve, groove, grip

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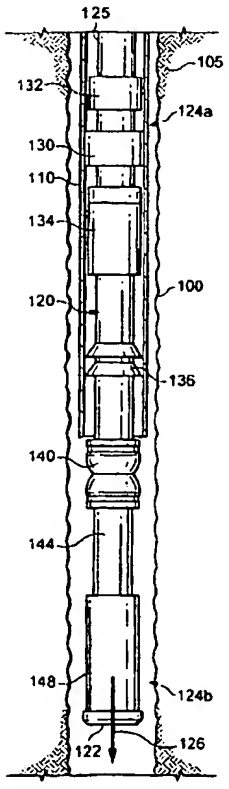

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AMENDED CLAIMS

[Received by the International Bureau on 27 July 2004 (27.07.04): new claims 13-60 has been added (9 pages)]

13. (New) An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

an anchoring mechanism adapted to mate with an end of the expandable tubular member;

a tubular member releasably coupled to the anchoring mechanism,

an adjustable expansion device coupled to the tubular member adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion device adapted to controllably longitudinally displace the adjustable expansion device relative to the expandable tubular member; and

a gripping device coupled to the locking adapted to controllably engage the expandable tubular member.

14. (New) The apparatus of claim 13 further comprising a locking device coupled to the actuator adapted to controllably engage the expandable tubular member.

15. (New) The apparatus of claim 13 further comprising a sealing device for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion device during radial expansion of the expandable tubular member.

16. (New) The apparatus of claim 13 wherein the gripping device comprises:

a tubular member having a plurality of tapered grooves defined on an exterior surface of the tubular member,

a retaining sleeve coupled to the tubular member and adapted to slidingly move longitudinally with respect to the tubular member, the retaining sleeve having a plurality of openings,

a plurality of gripping elements positioned within the tapered grooves, wherein when the retaining sleeve is in a first longitudinal configuration, portions of the gripping elements protrude through the plurality of openings, and when the retaining sleeve is in a second longitudinal configuration, portions of the gripping elements do not protrude through plurality of tapered openings.

17. (New) The apparatus of claim 13 wherein the anchoring device is a float shoe, comprising:

an expandable sleeve adapted to mate with the tubular member, wherein the tubular member is adapted to controllably expand the expandable sleeve to a larger outside dimension for radial expansion of the expandable sleeve to the expandable tubular member.

18. (New) The apparatus of claim 17 wherein the anchoring device comprises:

a first passage,

a second passage,

a seat within the first passage adapted to receive a plug,

a sliding valve disposed within the first passage, adapted to direct flow from the first passage to the second passage, and

a one-way valve coupled to the first and second passages.

19. (New) The apparatus of claim 13 wherein the anchoring mechanism is a packer.

20. (New) The apparatus of claim 13 wherein the packer is hydraulically actuated.

21. (New) The apparatus of claim 13 wherein the packer comprises:

a first passage,

a second passage,

a first seat within the first passage adapted to receive a plug, and

a sliding valve disposed within the first passage, adapted to direct flow from the first passage to the second passage.

22. (New) A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an adjustable expansion device, an anchoring device, and a coupling mechanism below the expandable tubular member such that the anchoring device contacts a bottom of the borehole,

increasing the outside dimension of the adjustable expansion device; and

displacing the adjustable expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member,

displacing the anchoring device upwardly relative to the expandable tubular member such that the anchoring device contacts the bottom of the expandable tubular member,

coupling the anchoring device to the bottom of the casing,

uncoupling the adjustable expansion device from the anchoring device, and

displacing the adjustable expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

23. (New) The method of claim 22, further comprising:

lowering the adjustable expansion device to couple the expansion device to the anchoring device, and

cementing the borehole, wherein the cementing flows through a flow path located in the anchoring device.

24. (New) The method of claim 22 further comprising expanding an expansion device coupled to the anchoring device such that the anchoring device couples to the casing.

25. (New) An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

an anchoring mechanism adapted to mate with an end of the expandable tubular member;

a tubular member releasably coupled to the anchoring mechanism,

an expansion device coupled to the tubular member adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion device adapted to controllably longitudinally displace the adjustable expansion device relative to the expandable tubular member; and

a gripping device coupled to the locking adapted to controllably engage the expandable tubular member.

26. (New) The apparatus of claim 25 further comprising a locking device coupled to the actuator adapted to controllably engage the expandable tubular member.

27. (New) The apparatus of claim 25 further comprising a sealing device for sealingly engaging the expandable tubular member adapted to define a pressure chamber proximate the expansion device during radial expansion of the expandable tubular member.

28. (New) The apparatus of claim 25 wherein the gripping device comprises:

a tubular member having a plurality of tapered grooves defined on an exterior surface of the tubular member,

a retaining sleeve coupled to the tubular member and adapted to slidingly move longitudinally with respect to the tubular member, the retaining sleeve having a plurality of openings,

a plurality of gripping elements positioned within the tapered grooves, wherein when the retaining sleeve is in a first longitudinal configuration, portions of the gripping elements protrude through the plurality of openings, and when the retaining sleeve is in a second longitudinal configuration, portions of the gripping elements do not protrude through plurality of tapered openings.

29. (New) The apparatus of claim 25 wherein the anchoring device is a float shoe, comprising:

an expandable sleeve adapted to mate with the tubular member, wherein the tubular member is adapted to controllably expand the expandable sleeve to a larger outside dimension for radial

expansion of the expandable sleeve to the expandable tubular member.

30. (New) The apparatus of claim 29 wherein the anchoring device comprises:

a first passage,

a second passage,

a seat within the first passage adapted to receive a plug,

a sliding valve disposed within the first passage, adapted to direct flow from the first passage to the second passage, and

a one-way valve coupled to the first and second passages.

31. (New) The apparatus of claim 25 wherein the anchoring mechanism is a packer.

32. (New) The apparatus of claim 25 wherein the packer is hydraulically actuated.

33. (New) The apparatus of claim 25 wherein the packer comprises:

a first passage,

a second passage,

a first seat within the first passage adapted to receive a plug, and

a sliding valve disposed within the first passage, adapted to direct flow from the first passage to the second passage.

34. (New) A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an expansion device, an anchoring device, and a coupling mechanism below the expandable tubular member;

displacing the expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member,

displacing the anchoring device upwardly relative to the expandable tubular member,

coupling the anchoring device to the bottom of the casing,

uncoupling the expansion device from the anchoring device, and

displacing the expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

35. (New) The method of claim 34, further comprising:

lowering the expansion device to couple the expansion device to the anchoring device, and

cementing the borehole, wherein the cementing flows through a flow path defined in the anchoring

device.

36. (New) The method of claim 34 further comprising expanding an expansion device coupled to the anchoring device such that the anchoring device couples to the casing.

37. (New) A gripping device for gripping a wellbore casing, comprising:

a tubular member having a plurality of tapered grooves defined on an exterior surface of the tubular member,

a retaining sleeve coupled to the tubular member and adapted to slidingly move longitudinally with respect to the tubular member, the retaining sleeve having a plurality of openings,

a plurality of gripping elements positioned within the tapered grooves, wherein when the retaining sleeve is in a first longitudinal configuration, portions of the gripping elements protrude through the plurality of openings, and when the retaining sleeve is in a second longitudinal configuration, portions of the gripping elements do not protrude through plurality of tapered openings.

38. (New) An anchoring device for anchoring the position of a wellbore casing, comprising:

an expandable sleeve adapted to mate with the wellbore casing.

39. (New) An anchoring device for anchoring the position of a wellbore casing, comprising:

a housing,

a first passage defined within the housing,

a second passage defined within the housing,

a seat within the first passage adapted to receive a plug,

a sliding valve disposed within the first passage, adapted to direct flow from the first passage to the second passage, and

a one-way valve coupled to the first and second passages.

40. (New) A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning an adjustable expansion mandrel, an anchoring device, and a coupling mechanism below the expandable tubular member such that the anchoring device contacts a bottom of the borehole,

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member,

means for displacing the anchoring device upwardly relative to the expandable tubular member such

that the anchoring device contacts the bottom of the expandable tubular member,
means for coupling the anchoring device to the bottom of the casing,
means for uncoupling the expansion mandrel from the anchoring device, and
means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

41. (New) The system of claim 40, further comprising:
means for lowering the adjustable expansion mandrel to couple the expansion mandrel to the anchoring device, and
means for cementing the borehole, wherein the cementing flows through a flow path located in the anchoring device.

42. (New) The system of claim 40 further comprising means for expanding an expansion device coupled to the anchoring device such that the anchoring device couples to the casing.

43. (New) A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:
means for positioning an adjustable expansion device, an anchoring device, and a coupling mechanism below the expandable tubular member such that the anchoring device contacts a bottom of the borehole,
means for increasing the outside dimension of the adjustable expansion device;
means for displacing the adjustable expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member,
means for displacing the anchoring device upwardly relative to the expandable tubular member such that the anchoring device contacts the bottom of the expandable tubular member,
means for coupling the anchoring device to the bottom of the casing,
means for uncoupling the adjustable expansion device from the anchoring device, and
means for displacing the adjustable expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

44. (New) The system of claim 43, further comprising:
means for lowering the adjustable expansion device to couple the expansion device to the anchoring device, and
means for cementing the borehole, wherein the cementing flows through a flow path located in the

anchoring device.

45. (New) The system of claim 43 further comprising means for expanding an expansion device coupled to the anchoring device such that the anchoring device couples to the casing.

46. (New) A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning an expansion device, an anchoring device, and a coupling mechanism below the expandable tubular member;

means for displacing the expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member,

means for displacing the anchoring device upwardly relative to the expandable tubular member,

means for coupling the anchoring device to the bottom of the casing,

means for uncoupling the expansion device from the anchoring device, and

means for displacing the expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

47. (New) The system of claim 46, further comprising:

means for lowering the expansion device to couple the expansion device to the anchoring device, and

means for cementing the borehole, wherein the cementing flows through a flow path defined in the anchoring device.

48. (New) The method of claim 46 further comprising means for expanding an expansion device coupled to the anchoring device such that the anchoring device couples to the casing.

49. (New) A method of gripping a wellbore casing, comprising:

gripping the interior surface of the wellbore casing at a plurality of discrete spaced apart locations.

50. (New) A method of anchoring the position of a wellbore casing, comprising:

radially expanding and plastically deforming a sleeve within the wellbore casing into contact with the interior surface of the wellbore casing.

51. (New) A system for gripping a wellbore casing, comprising:

means for gripping the interior surface of the wellbore casing at a plurality of discrete spaced apart locations; and

means for actuating the means for gripping.

52. (New) A system for anchoring the position of a wellbore casing, comprising:

means for radially expanding and plastically deforming a sleeve within the wellbore casing into contact with the interior surface of the wellbore casing; and

means for controlling the means for radially expanding and plastically deforming the sleeve.

53. (New) A method of radially expanding and plastically deforming a tubular member, comprising:

pressurizing an interior portion of the tubular member; and

displacing an expansion device through the pressurized interior portion of the tubular member.

54. (New) The method of claim 53, wherein pressurizing an interior portion of the tubular member comprises pressurizing an annular interior portion of the tubular member.

55. (New) The method of claim 53, wherein displacing an expansion device through the pressurized interior portion of the tubular member comprises pulling the expansion device through the pressurized interior portion of the tubular member.

56. (New) The method of claim 53, wherein pulling the expansion device through the pressurized interior portion of the tubular member comprises using the operating pressure of the pressurized interior portion of the tubular member to pull the expansion device through the pressurized interior portion of the tubular member.

57. (New) A system for radially expanding and plastically deforming a tubular member, comprising:

means for pressurizing an interior portion of the tubular member; and

means for displacing an expansion device through the pressurized interior portion of the tubular member.

58. (New) The system of claim 57, wherein means for pressurizing an interior portion of the tubular member comprises means for pressurizing an annular interior portion of the tubular member.

59. (New) The system of claim 57, wherein means for displacing an expansion device through the pressurized interior portion of the tubular member comprises means for pulling the expansion device through the pressurized interior portion of the tubular member.

60. (New) The system of claim 57, wherein means for pulling the expansion device through the pressurized interior portion of the tubular member comprises means for using the operating pressure of the pressurized interior portion of the tubular member to pull the expansion device through the pressurized interior portion of the tubular member.

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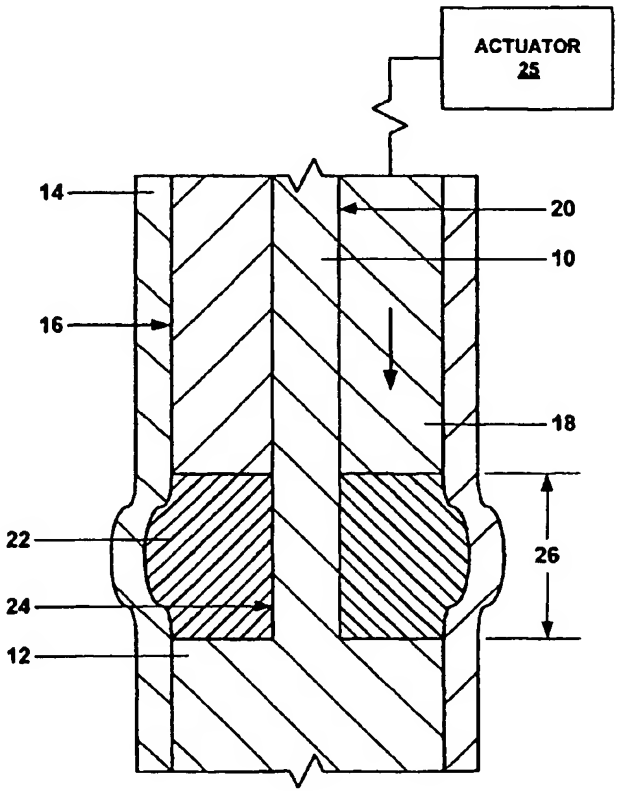
(54) Title: SYSTEM FOR RADIALLY EXPANDING A TUBULAR MEMBER

(57) Abstract: A system for radially expanding a tubular member (14).



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SYSTEM FOR RADIALLY EXPANDING A TUBULAR MEMBER

Cross Reference To Related Applications

[001] The present application claims the benefit of the filing dates of (1) U.S. provisional patent application serial no. 60/383,917, attorney docket no 25791.89, filed on 5/29/2002, the disclosure of which is incorporated herein by reference.

[002] The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/3318,386, attorney docket no.

25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001; (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001; (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no 25791.92, filed on 1/7/2002; (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002; (34) U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/2002; and (35) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, the disclosures of which are incorporated herein by reference.

Background of the Invention

[003] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration and production.

[004] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[005] The present invention is directed to overcoming one or more of the limitations of the existing processes for forming and repairing wellbore casings.

Summary of the Invention

[006] According to one aspect of the present invention, a method of radially expanding and plastically deforming at least a portion of an expandable tubular member is provided that includes positioning a resilient member within the interior of the expandable tubular member, and compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

[007] According to another aspect of the present invention, a system for radially expanding and plastically deforming at least a portion of an expandable tubular member is provided that includes means for positioning a resilient member within the interior of the expandable tubular member, and

means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

[008] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a support member, a resilient member coupled to the support member, and an actuator operably coupled to the resilient member for controllably compressing the resilient member to thereby radially expand and plastically deform the expandable tubular member.

Brief Description of the Drawings

[009] Fig. 1a is a fragmentary cross-sectional illustration of an exemplary embodiment of an apparatus for radially expanding and plastically deforming a tubular member.

[0010] Fig. 1b is a fragmentary cross-sectional illustration of the apparatus of Fig. 1a after compressing the resilient expansion member to radially expand and plastically deform a portion of the expandable tubular member.

[0011] Fig. 1c is a fragmentary cross-sectional illustration of the apparatus of Fig. 1b after permitting the resilient expansion member to re-expand in the longitudinal direction.

[0012] Fig. 1d is a fragmentary cross-sectional illustration of the apparatus of Fig. 1c after removing the resilient expansion member from the expandable tubular member.

[0013] Fig. 1e is a fragmentary cross sectional illustration of the apparatus of Fig. 1d after positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member.

[0014] Fig. 1f is a fragmentary cross-sectional illustration of the apparatus of Fig. 1e after expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member.

[0015] Fig. 1g is a fragmentary cross sectional illustration of the apparatus of Fig. 1f after displacing the adjustable expansion cone relative to the expandable tubular member to radially expand and plastically deform at least a portion of the expandable tubular member.

[0016] Fig. 2a is a fragmentary cross-sectional illustration of the apparatus of Fig. 1a after being positioned within a preexisting structure.

[0017] Fig. 2b is a fragmentary cross sectional of the apparatus of Fig. 2a after compressing the resilient expansion member to radially expand and plastically deform a portion of the expandable tubular member into intimate contact with the interior surface of the preexisting structure.

[0018] Fig. 2c is a fragmentary cross-sectional illustration of the apparatus of Fig. 2b after permitting the resilient expansion member to re-expand in the longitudinal direction.

[0019] Fig. 2d is a fragmentary cross-sectional illustration of the apparatus of Fig. 2c after removing the resilient expansion member from the expandable tubular member.

[0020] Fig. 2e is a fragmentary cross sectional illustration of the apparatus of Fig. 2d after positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member.

[0021] Fig. 2f is a fragmentary cross-sectional illustration of the apparatus of Fig. 2e after expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member.

[0022] Fig. 2g is a fragmentary cross sectional illustration of the apparatus of Fig. 2f after displacing the adjustable expansion cone relative to the expandable tubular member to radially expand and plastically deform at least a portion of the expandable tubular member.

[0023] Fig. 3 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of the expandable tubular member of Fig. 2a at a plurality of discrete locations by repeating the operational steps of Figs. 2a-2c a plurality of times within the preexisting structure.

[0024] Fig. 4 is a fragmentary cross sectional illustration of an alternative embodiment of the apparatus of Fig. 1a in which an adjustable expansion cone is provided below the resilient expansion member.

Detailed Description of the Illustrative Embodiments

[0025] Referring to Fig. 1a, a cylindrical member 10 that includes a flange 12 at one end is positioned within a first tubular member 14 that defines a passage 16 for receiving and mating with the flange of the cylindrical member. A second tubular member 18 that is received within and mates with the passage 16 of the first tubular member 14 defines a passage 20 that receives and mates with another end of the cylindrical member 10, and a third tubular member 22 that is also received within and mates with the passage of the first tubular member defines a passage 24 that receives and mates with an intermediate portion of the cylindrical member. In this manner, the third tubular member 22 is positioned between an end face of the second tubular member 18 and an end face of the flange 12 of the cylindrical member 10. An actuator 25 is operably coupled to the second tubular member 18 for controllably displacing the second tubular member relative to the cylindrical member 10 in the longitudinal direction. In an exemplary embodiment, the cylindrical member 10, the first tubular member 14, and the second tubular member 18 are fabricated from rigid materials such as, for example, aluminum or steel, and the third tubular member 22 is fabricated from resilient materials such as, for example, natural rubber, synthetic rubber, and/or an elastomeric material.

[0026] In an exemplary embodiment, as illustrated in Fig. 1b, the second tubular member 18 is then displaced downwardly in the longitudinal direction toward the flange 12 of the cylindrical member 10 by the actuator 25. As a result, the resilient third tubular member 22 is compressed in the longitudinal direction and expanded in the radial direction thereby radially expanding and plastically deforming the portion 26 of the first tubular member 14 proximate the radially expanded portion of the third tubular member 22. In an experimental implementation, the inside diameter of the portion

26 of the first tubular member 14 proximate the radially expanded portion of the third resilient tubular member 22 was unexpectedly increased by up to about 22 percent.

[0027] In an exemplary embodiment, as illustrated in Fig. 1c, the second tubular member 18 is then displaced upwardly in the longitudinal direction away from the flange 12 of the cylindrical member 10 by the actuator 25. As a result, the resilient third tubular member 22 is no longer compressed in the longitudinal direction or expanded in the radial direction. As a result, as illustrated in Fig. 1d, the cylindrical member 10, the second tubular member 18, and the third tubular member 22 may then be removed from the passage 16 of the first tubular member 14.

[0028] In an exemplary embodiment, as illustrated in Fig. 1e, an adjustable expansion cone 28 is then positioned within the radially expanded portion 26 of the first tubular member 14 using a support member 30.

[0029] In an exemplary embodiment, as illustrated in Fig. 1f, the outside diameter of the adjustable expansion cone 28 is then increased to mate with the inside surface of at least a portion of the radially expanded portion 26 of the first tubular member 14. The adjustable expansion cone 28 is then displaced upwardly relative to the first tubular member 14. In several alternative embodiments, the adjustable expansion cone 28 is displaced upwardly relative to the first tubular member 14 by pulling the adjustable expansion cone 28 upwardly and/or by pressurizing the region 32 of the first tubular member below the adjustable expansion cone. In an exemplary embodiment, as illustrated in Fig. 1g, as a result of the upward displacement of the adjustable expansion cone 28 relative to the first tubular member 14, an upper portion 34 of the first tubular member is radially expanded and plastically deformed.

[0030] In several exemplary embodiments, the upper portion 34 of the first tubular member 14 is radially expanded and plastically deformed using the adjustable expansion cone 28 in a conventional manner and/or using one or more of the methods and apparatus disclosed in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application

serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001; (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001; (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no 25791.92, filed on 1/7/2002; (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002; (34) U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/2002; and (35) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, the disclosures of which are incorporated herein by reference.

[0031] In several alternative embodiments, the upper portion 34 of the first tubular member 14 is radially expanded and plastically deformed using other conventional methods for radially expanding and plastically deforming tubular members such as, for example, internal pressurization and/or roller expansion devices such as, for example, that disclosed in U.S. patent application publication no. US 2001/0045284 A1, the disclosure of which is incorporated herein by reference.

[0032] In several alternative embodiments, the lower portion 36 of the first tubular member 14 is radially expanded and plastically deformed instead of, or in addition to, the upper portion 34.

[0033] Referring to Fig. 2a, in an alternative embodiment, the cylindrical member 10, the first tubular member 14, the second tubular member 18, and the third tubular member 22 are positioned

within the interior of a preexisting structure 38. In several exemplary embodiments, the preexisting structure 38 may be a wellbore, a wellbore casing, a pipeline, or a structural support.

[0034] In an exemplary embodiment, as illustrated in Fig. 2b, the second tubular member 18 is then displaced downwardly in the longitudinal direction toward the flange 12 of the cylindrical member 10 using the actuator 25. As a result, the resilient third tubular member 22 is compressed in the longitudinal direction and expanded in the radial direction thereby radially expanding and plastically deforming the portion 26 of the first tubular member 14 proximate the radially expanded portion of the third tubular member 22 into intimate contact with the interior surface of the preexisting structure 38. In an experimental implementation, the inside diameter of the portion 26 of the first tubular member 14 proximate the radially expanded portion of the third resilient tubular member 22 was unexpectedly increased by up to about 22 percent. In an experimental implementation, the contact pressure between the radially expanded and plastically deformed portion 26 of the first tubular member 14 and the interior surface of the preexisting structure 38 provided a fluid tight seal and supported the first tubular member.

[0035] In an exemplary embodiment, as illustrated in Fig. 2c, the second tubular member 18 is then displaced upwardly in the longitudinal direction away from the flange 12 of the cylindrical member 10 using the actuator 25. As a result, the resilient third tubular member 22 is no longer compressed in the longitudinal direction or expanded in the radial direction. As a result, as illustrated in Fig. 2d, the cylindrical member 10, the second tubular member 18, and the third tubular member 22 may then be removed from the passage 16 of the first tubular member 14.

[0036] In an exemplary embodiment, as illustrated in Fig. 2e, an adjustable expansion cone 28 is then positioned within the radially expanded portion 26 of the first tubular member 14 using a support member 30.

[0037] In an exemplary embodiment, as illustrated in Fig. 2f, the outside diameter of the adjustable expansion cone 28 is then increased to mate with the inside surface of at least a portion of the radially expanded portion 26 of the first tubular member 14. The adjustable expansion cone 28 is then displaced upwardly relative to the first tubular member 14. In several alternative embodiments, the adjustable expansion cone 28 is displaced upwardly relative to the first tubular member 14 by pulling the adjustable expansion cone 28 upwardly and/or by pressurizing the region 32 of the first tubular member below the adjustable expansion cone. In an exemplary embodiment, as illustrated in Fig. 2g, as a result of the upward displacement of the adjustable expansion cone 28 relative to the first tubular member 14, an upper portion 34 of the first tubular member is radially expanded and plastically deformed. In an exemplary experimental implementation, the upward displacement of the adjustable expansion cone 28 relative to the first tubular member 14, caused the upper portion 34 of the first tubular member to be radially expanded and plastically deformed into intimate contact with the interior surface of the preexisting structure.

[0038] In an alternative embodiment, as illustrated in Fig. 3, the first tubular member 14 is radially expanded and plastically deformed into intimate contact with the preexisting structure 38 at a plurality of spaced apart locations by operating the cylindrical member 10, the first tubular member 14, the second tubular member 18, and the third tubular member 22 a plurality of times as described above with reference to Figs. 2a-2c. As a result, radially expanded and plastically deformed portions, 26a and 26b, of the first tubular member 14 are thereby radially expanded and plastically deformed into intimate contact with interior surface of the preexisting structure 38. In an exemplary experimental implementation, the radially expanded and plastically deformed portions, 26a and 26b, of the first tubular member 14 provided a fluid tight seal between the radially expanded portions and the interior surface of the preexisting structure 38. In an exemplary embodiment, the intermediate portion 40 of the first tubular member 14, positioned between the radially expanded and plastically deformed portions, 26a and 26b, of the first tubular member, includes one or more openings, slots, and/or apertures for conveying fluidic materials into and/or out of the first tubular member. In this manner, fluidic materials within a subterranean formation 42 positioned proximate the intermediate portion may be extracted into the interior 16 of the first tubular member. Or, alternatively, fluidic materials may be injected into the subterranean formation. In several alternative embodiments, the subterranean formation 42 may include a source of hydrocarbons such as, for example, petroleum and/or natural gas, and/or a source of geothermal energy.

[0039] In an alternative embodiments, as illustrated in Fig. 4, an adjustable expansion cone 42 is coupled to the cylindrical member 10 below the resilient third tubular member 22. In this manner, during operation, after expanding the resilient tubular member 22 in the radial direction to thereby radially expand and plastically deform the first tubular member 14, the adjustable expansion cone 42 may then be positioned proximate the radially expanded portion of the first tubular member and radially expanded. The adjustable expansion cone 42 may then be displaced upwardly and/or downwardly relative to the first tubular member 14 in the longitudinal direction to thereby radially expand and plastically deform at least a portion of the first tubular member.

[0040] A method of radially expanding and plastically deforming at least a portion of an expandable tubular member has been described that includes positioning a resilient member within the interior of the expandable tubular member, and compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the inside diameter of the radially expanded portion of the expandable tubular member is increased by up to about 22 percent during the radial expansion and plastic deformation. In an exemplary embodiment, the method further includes positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member, expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member, and displacing the adjustable expansion cone relative to the expandable tubular member in the longitudinal direction

to radially expand and plastically deform another portion of the expandable tubular member. In an exemplary embodiment, the method further includes decompressing the resilient member within the interior of the expandable tubular member, positioning the resilient member to another location within the interior of the expandable tubular member, and compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member. In an exemplary embodiment, the method further includes positioning the expandable tubular member within a preexisting structure. In an exemplary embodiment, the preexisting structure includes a wellbore. In an exemplary embodiment, the preexisting structure includes a wellbore casing. In an exemplary embodiment, the preexisting structure includes a pipeline. In an exemplary embodiment, the preexisting structure includes a structural support. In an exemplary embodiment, the method further includes compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member into contact with the interior surface of the preexisting structure. In an exemplary embodiment, the method further includes decompressing the resilient member within the interior of the expandable tubular member, positioning the resilient member to another location within the interior of the expandable tubular member, and compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member into contact with the interior surface of the preexisting structure. In an exemplary embodiment, the intermediate portion of the expandable tubular member positioned between the radially expanded and plastically deformed portions defines one or more radial openings for conveying fluidic materials between the interiors of the expandable tubular member and the preexisting structure. In an exemplary embodiment, the preexisting structure includes a wellbore that traverses a subterranean formation. In an exemplary embodiment, the subterranean formation includes a source of geothermal energy. In an exemplary embodiment, the subterranean formation includes a source of hydrocarbons. In an exemplary embodiment, the method further includes compressing the resilient member in the longitudinal direction within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the resilient member is a resilient tubular member. In an exemplary embodiment, the expandable tubular member is a solid expandable tubular member. In an exemplary embodiment, the expandable tubular member defines one or more radial openings for conveying fluidic materials.

[0041] A system for radially expanding and plastically deforming at least a portion of an expandable tubular member has been described that includes means for positioning a resilient member within the interior of the expandable tubular member, and means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the inside diameter of the radially expanded portion of the expandable tubular member is increased by up to

about 22 percent during the radial expansion and plastic deformation. In an exemplary embodiment, the system further includes means for positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member, means for expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member, and means for displacing the adjustable expansion cone relative to the expandable tubular member in the longitudinal direction to radially expand and plastically deform another portion of the expandable tubular member. In an exemplary embodiment, the system further includes means for decompressing the resilient member within the interior of the expandable tubular member, means for positioning the resilient member to another location within the interior of the expandable tubular member, and means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member. In an exemplary embodiment, the system further includes means for positioning the expandable tubular member within a preexisting structure. In an exemplary embodiment, the preexisting structure includes a wellbore. In an exemplary embodiment, the preexisting structure includes a wellbore casing. In an exemplary embodiment, the preexisting structure includes a pipeline. In an exemplary embodiment, the preexisting structure includes a structural support. In an exemplary embodiment, the system further includes means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member into contact with the interior surface of the preexisting structure. In an exemplary embodiment, the system further includes means for decompressing the resilient member within the interior of the expandable tubular member, means for positioning the resilient member to another location within the interior of the expandable tubular member, and means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member into contact with the interior surface of the preexisting structure. In an exemplary embodiment, an intermediate portion of the expandable tubular member positioned between the radially expanded and plastically deformed portions defines one or more radial openings for conveying fluidic materials between the interiors of the expandable tubular member and the preexisting structure. In an exemplary embodiment, the preexisting structure includes a wellbore that traverses a subterranean formation. In an exemplary embodiment, the subterranean formation includes a source of geothermal energy. In an exemplary embodiment, the subterranean formation includes a source of hydrocarbons. In an exemplary embodiment, the system further includes means for compressing the resilient member in the longitudinal direction within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the resilient member includes a resilient tubular member. In an exemplary embodiment, the expandable tubular member is a solid expandable tubular

member. In an exemplary embodiment, the expandable tubular member defines one or more radial openings for conveying fluidic materials.

[0042] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a support member, a resilient member coupled to the support member, and an actuator operably coupled to the resilient member for controllably compressing the resilient member to thereby radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the resilient member includes a tubular resilient member. In an exemplary embodiment, the apparatus further includes an adjustable expansion cone coupled to the support member. In an exemplary embodiment, the actuator is adapted to compress the resilient member in the longitudinal direction and thereby cause the resilient member to expand in the radial direction. In an exemplary embodiment, the support member is fabricated from a rigid material. In an exemplary embodiment, the rigid material is selected from the group consisting of steel and aluminum. In an exemplary embodiment, the resilient member is fabricated from materials selected from the group consisting of natural rubber, synthetic rubber, and elastomeric material.

[0043] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments.

[0044] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. A method of radially expanding and plastically deforming at least a portion of an expandable tubular member, comprising:

positioning a resilient member within the interior of the expandable tubular member; and

compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

2. The method of claim 1, wherein the inside diameter of the radially expanded portion of the expandable tubular member is increased by up to about 22 percent during the radial expansion and plastic deformation.

3. The method of claim 1, further comprising:

positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member;

expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member; and

displacing the adjustable expansion cone relative to the expandable tubular member in the longitudinal direction to radially expand and plastically deform another portion of the expandable tubular member.

4. The method of claim 1, further comprising:

decompressing the resilient member within the interior of the expandable tubular member;

positioning the resilient member to another location within the interior of the expandable tubular member; and

compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

5. The method of claim 1, further comprising:

positioning the expandable tubular member within a preexisting structure.

6. The method of claim 5, wherein the preexisting structure comprises a wellbore.

7. The method of claim 5, wherein the preexisting structure comprises a wellbore casing.

8. The method of claim 5, wherein the preexisting structure comprises a pipeline.

9. The method of claim 5, wherein the preexisting structure comprises a structural support.

10. The method of claim 5, further comprising:

compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member into contact with the interior surface of the preexisting structure.

11. The method of claim 10, further comprising:

decompressing the resilient member within the interior of the expandable tubular member;

positioning the resilient member to another location within the interior of the expandable tubular member; and

compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member into contact with the interior surface of the preexisting structure.

12. The method of claim 11, wherein an intermediate portion of the expandable tubular member positioned between the radially expanded and plastically deformed portions defines one or more radial openings for conveying fluidic materials between the interiors of the expandable tubular member and the preexisting structure.

13. The method of claim 12, wherein the preexisting structure comprises a wellbore that traverses a subterranean formation.

14. The method of claim 13, wherein the subterranean formation comprises a source of geothermal energy.

15. The method of claim 13, wherein the subterranean formation comprises a source of hydrocarbons.

16. The method of claim 1, further comprising:

compressing the resilient member in the longitudinal direction within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

17. The method of claim 1, wherein the resilient member comprises a resilient tubular member.

18. The method of claim 1, wherein the expandable tubular member comprises a solid expandable tubular member.

19. The method of claim 1, wherein the expandable tubular member defines one or more radial openings for conveying fluidic materials.

20. A system for radially expanding and plastically deforming at least a portion of an expandable tubular member, comprising:

means for positioning a resilient member within the interior of the expandable tubular member; and

means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

21. The system of claim 20, wherein the inside diameter of the radially expanded portion of the expandable tubular member is increased by up to about 22 percent during the radial expansion and plastic deformation.

22. The system of claim 20, further comprising:

means for positioning an adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member;

means for expanding the adjustable expansion cone within the radially expanded and plastically deformed portion of the expandable tubular member; and

means for displacing the adjustable expansion cone relative to the expandable tubular member in the longitudinal direction to radially expand and plastically deform another portion of the expandable tubular member.

23. The system of claim 20, further comprising:

means for decompressing the resilient member within the interior of the expandable tubular member;

means for positioning the resilient member to another location within the interior of the expandable tubular member; and

means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

24. The system of claim 20, further comprising:

means for positioning the expandable tubular member within a preexisting structure.

25. The system of claim 24, wherein the preexisting structure comprises a wellbore.

26. The system of claim 24, wherein the preexisting structure comprises a wellbore casing.

27. The system of claim 24, wherein the preexisting structure comprises a pipeline.

28. The system of claim 24, wherein the preexisting structure comprises a structural support.

29. The system of claim 24, further comprising:

means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member into contact with the interior surface of the preexisting structure.

30. The system of claim 29, further comprising:

means for decompressing the resilient member within the interior of the expandable tubular member;

means for positioning the resilient member to another location within the interior of the expandable tubular member; and

means for compressing the resilient member within the interior of the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member into contact with the interior surface of the preexisting structure.

31. The system of claim 30, wherein an intermediate portion of the expandable tubular member positioned between the radially expanded and plastically deformed portions defines one or more radial openings for conveying fluidic materials between the interiors of the expandable tubular member and the preexisting structure.

32. The system of claim 31, wherein the preexisting structure comprises a wellbore that traverses a subterranean formation.

33. The system of claim 32, wherein the subterranean formation comprises a source of geothermal energy.

34. The system of claim 32, wherein the subterranean formation comprises a source of hydrocarbons.

35. The system of claim 20, further comprising:

means for compressing the resilient member in the longitudinal direction within the interior of the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

36. The system of claim 20, wherein the resilient member comprises a resilient tubular member.

37. The system of claim 20, wherein the expandable tubular member comprises a solid expandable tubular member.

38. The system of claim 20, wherein the expandable tubular member defines one or more radial openings for conveying fluidic materials.

39. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

a resilient member coupled to the support member; and

an actuator operably coupled to the resilient member for controllably compressing the resilient member to thereby radially expand and plastically deform the expandable tubular member.

40. The apparatus of claim 39, wherein the resilient member comprises a tubular resilient member.

41. The apparatus of claim 39, further comprising an adjustable expansion cone coupled to the support member.

42. The apparatus of claim 39, wherein the actuator is adapted to compress the resilient member in the longitudinal direction and thereby cause the resilient member to expand in the radial direction.

43. The apparatus of claim 39, wherein the support member is fabricated from a rigid material.

44. The apparatus of claim 43, wherein the rigid material is selected from the group consisting of steel and aluminum.

45. The apparatus of claim 39, wherein the resilient member is fabricated from materials selected from the group consisting of natural rubber, synthetic rubber, and elastomeric material.

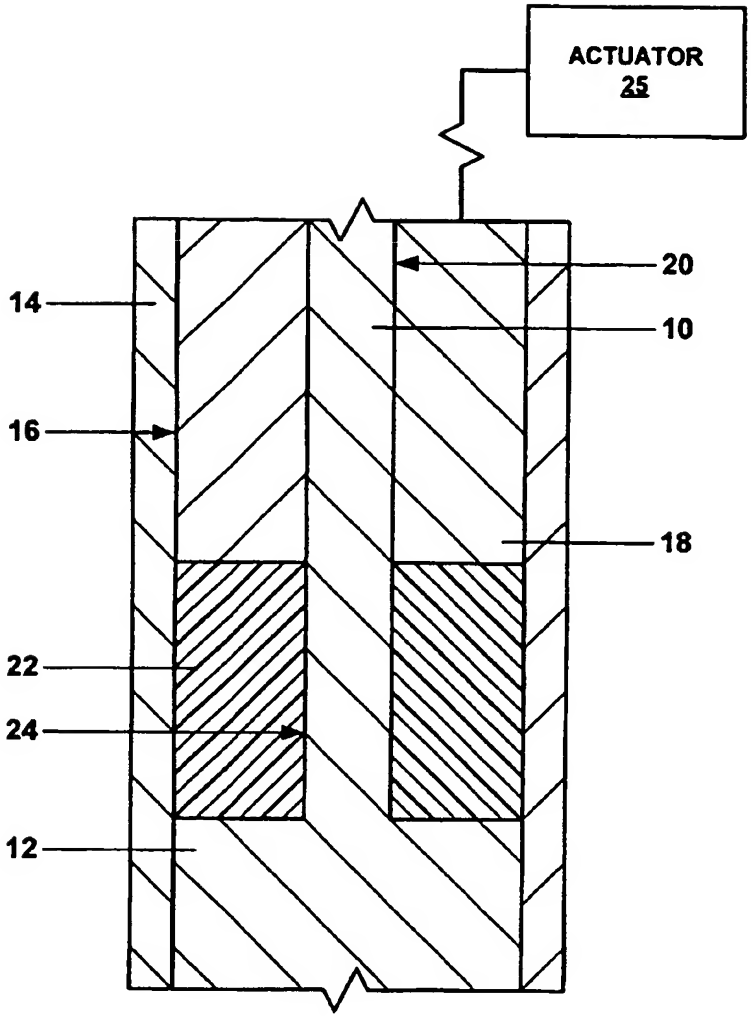

Fig. 1a

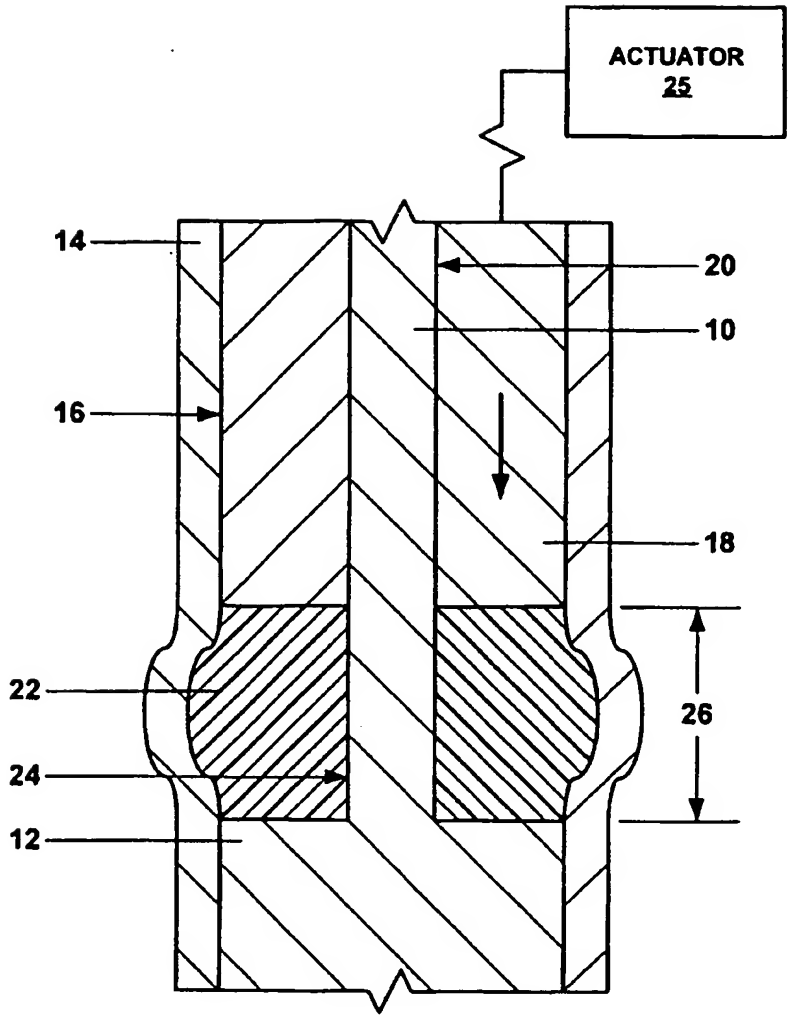

Fig. 1b

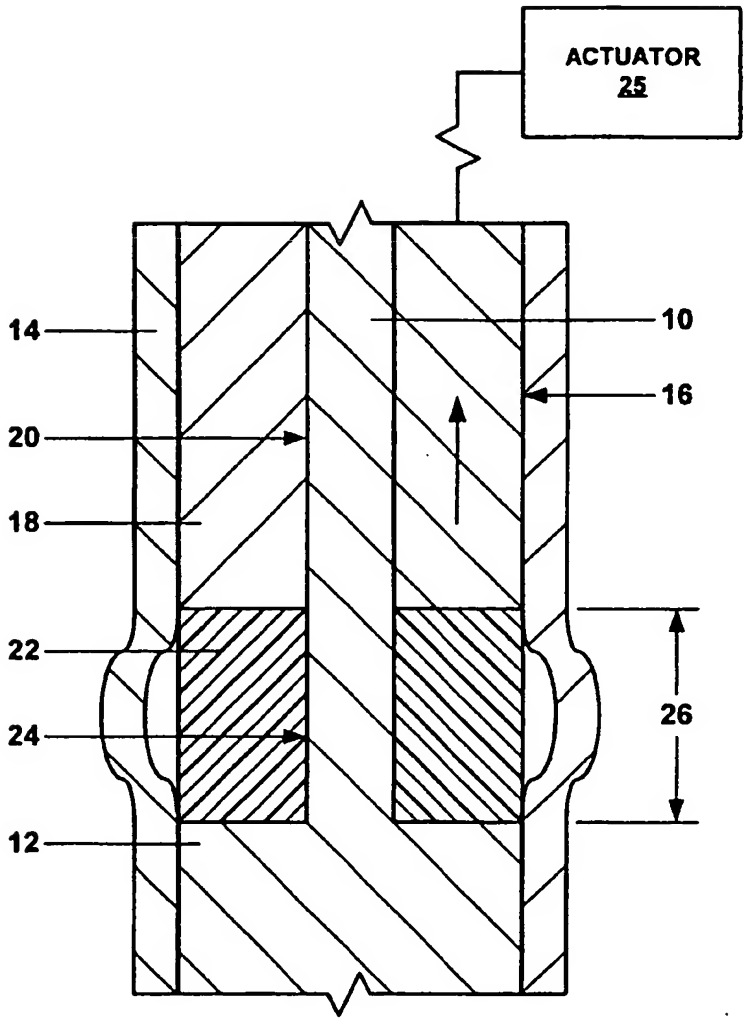

Fig. 1c

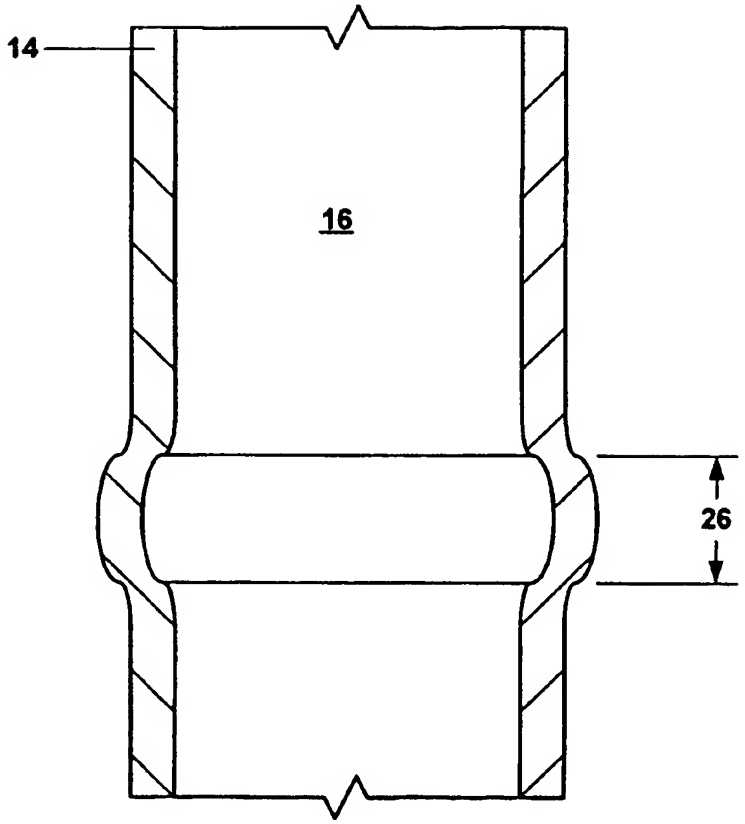

Fig. 1d

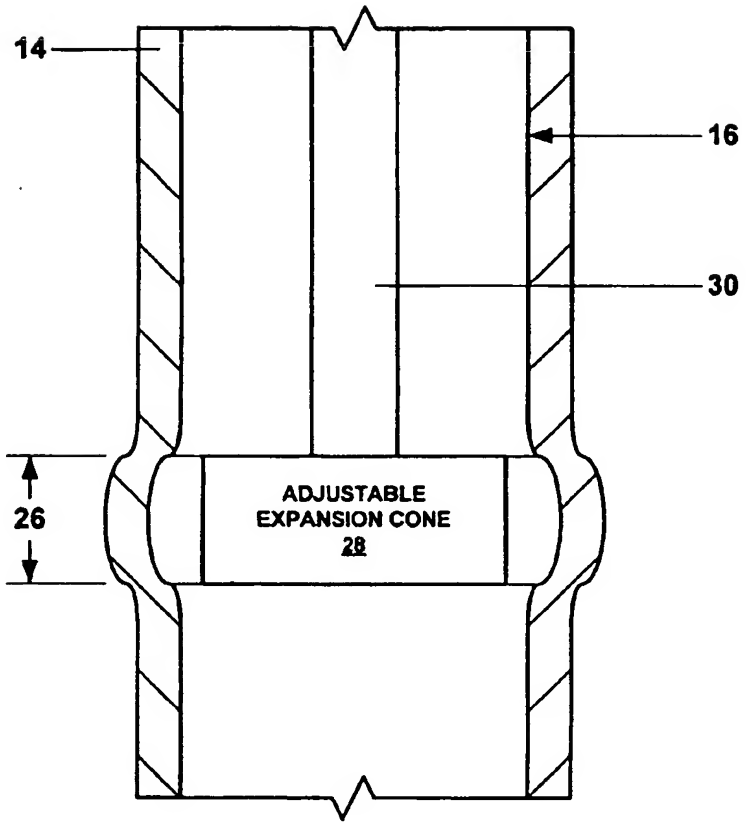

Fig. 1e

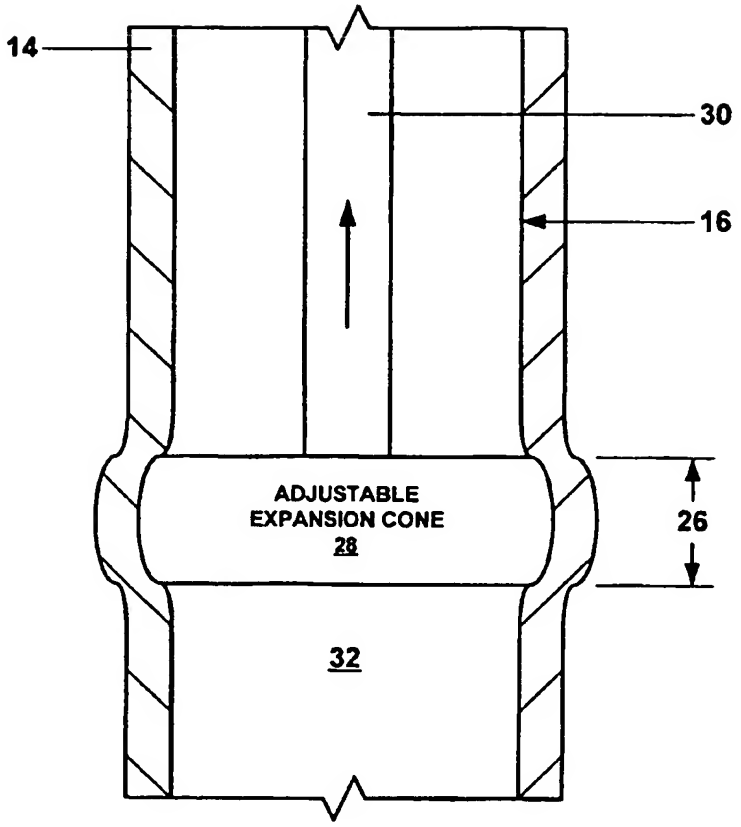

Fig. 1f

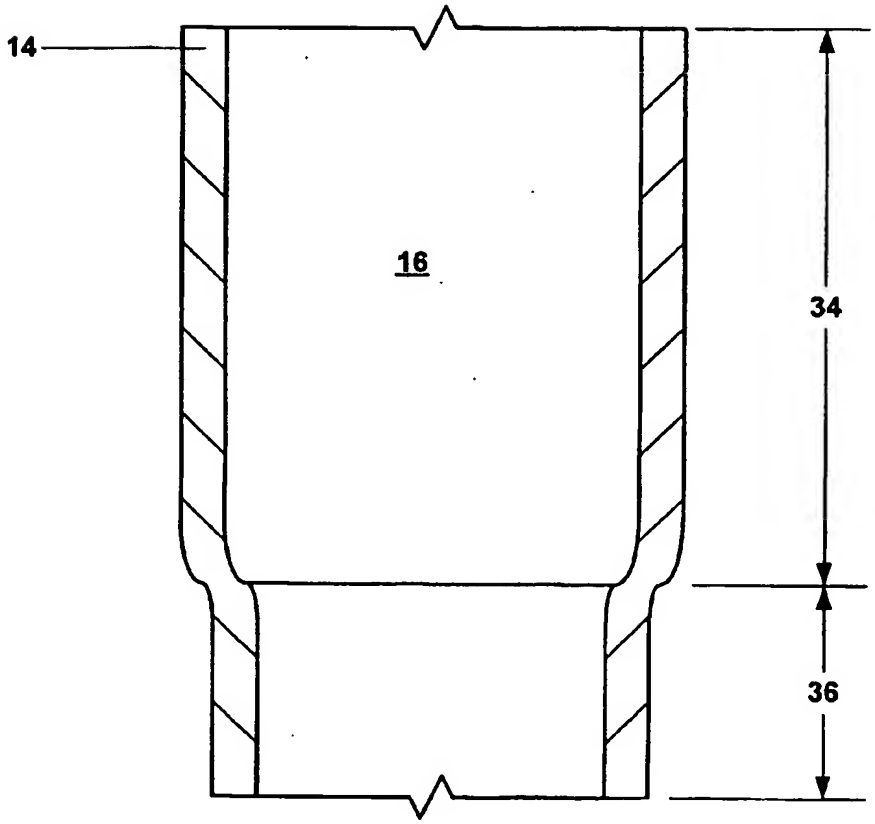

Fig. 1g

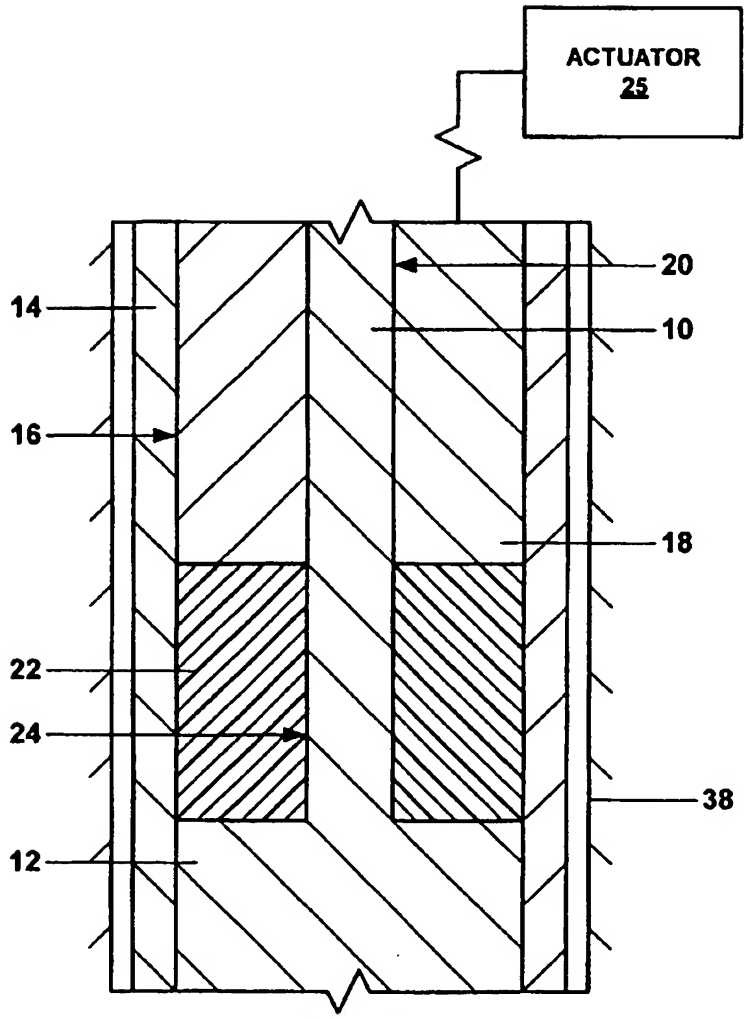

Fig. 2a

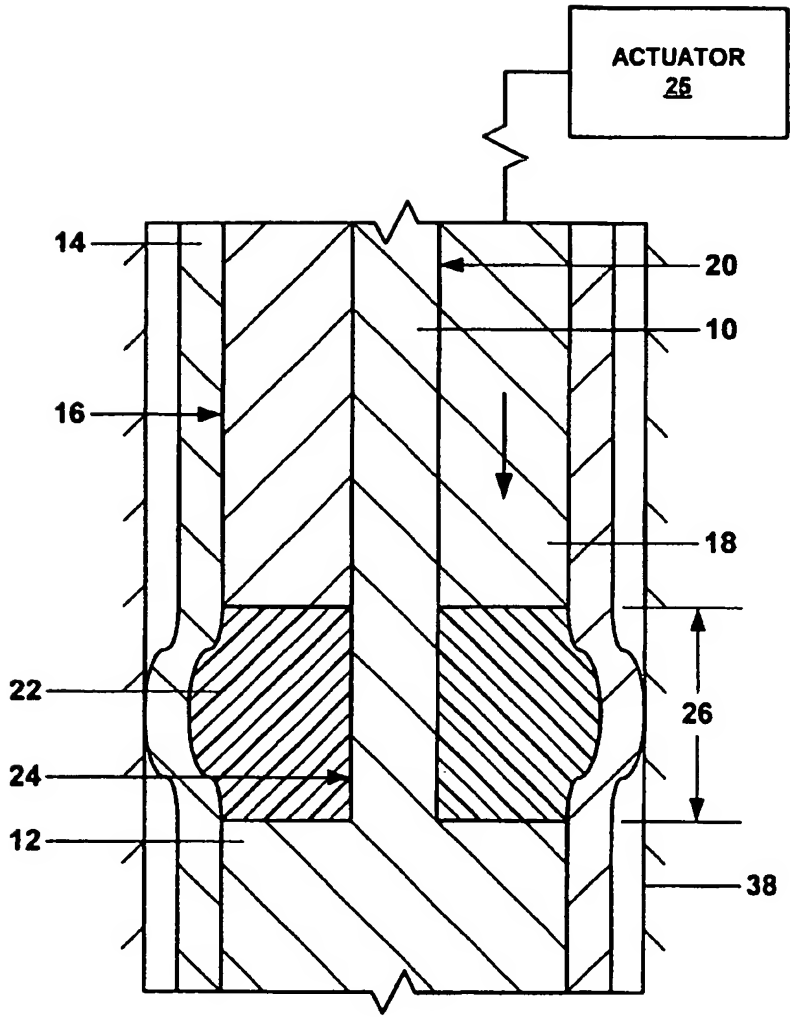

Fig. 2b

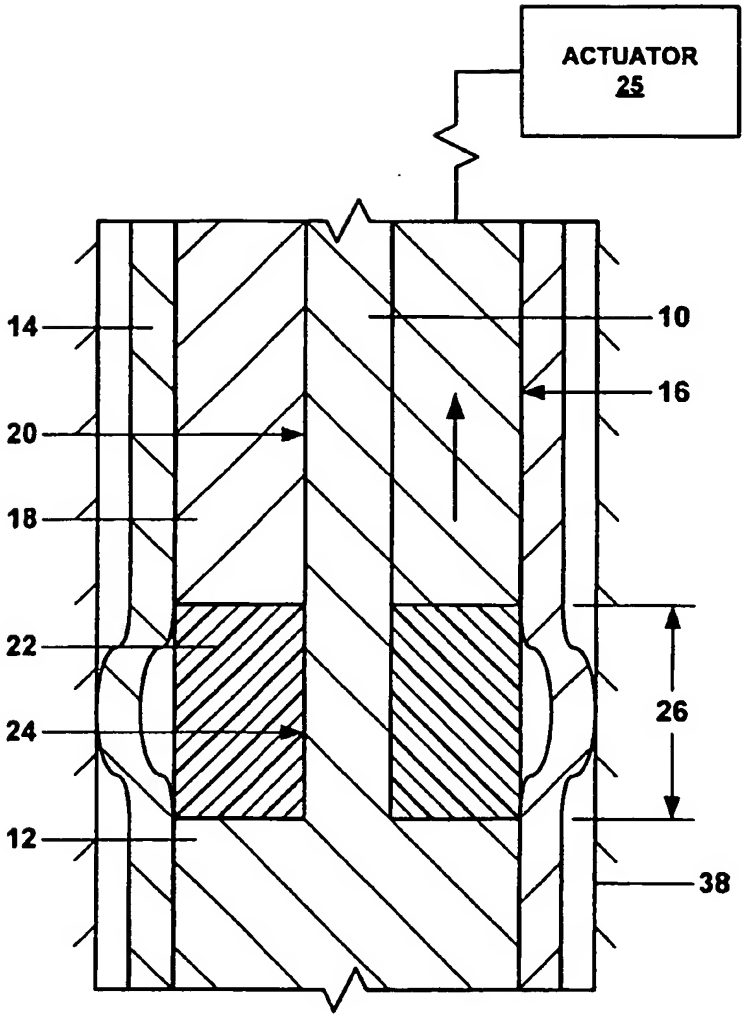

Fig. 2c

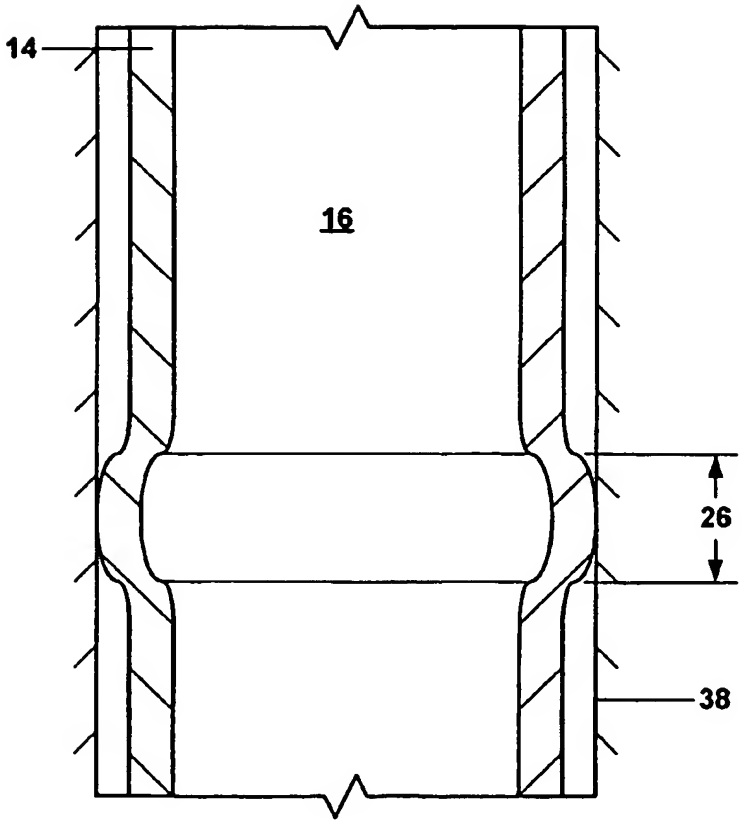

Fig. 2d

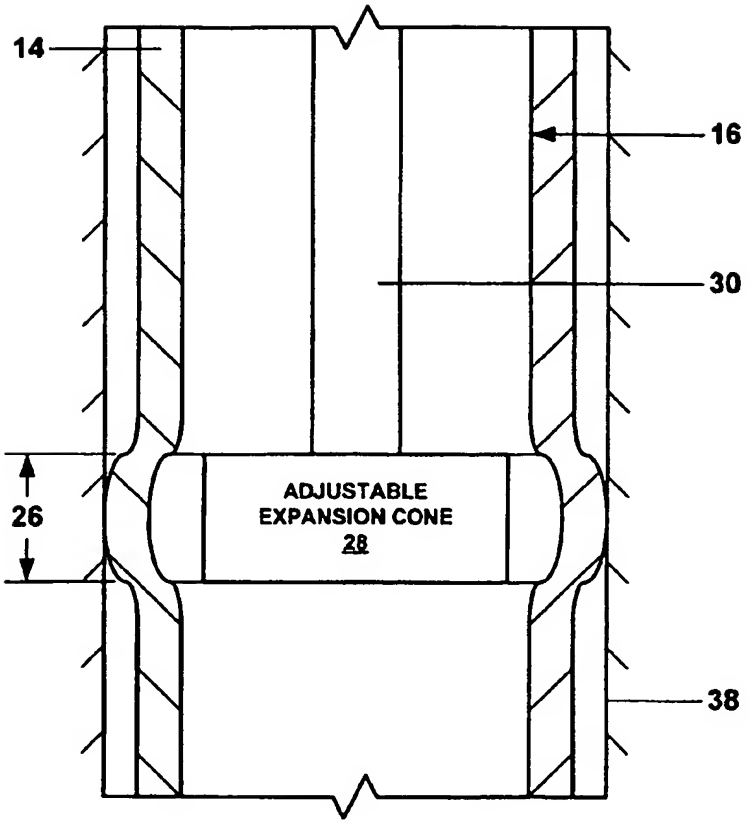

Fig. 2e

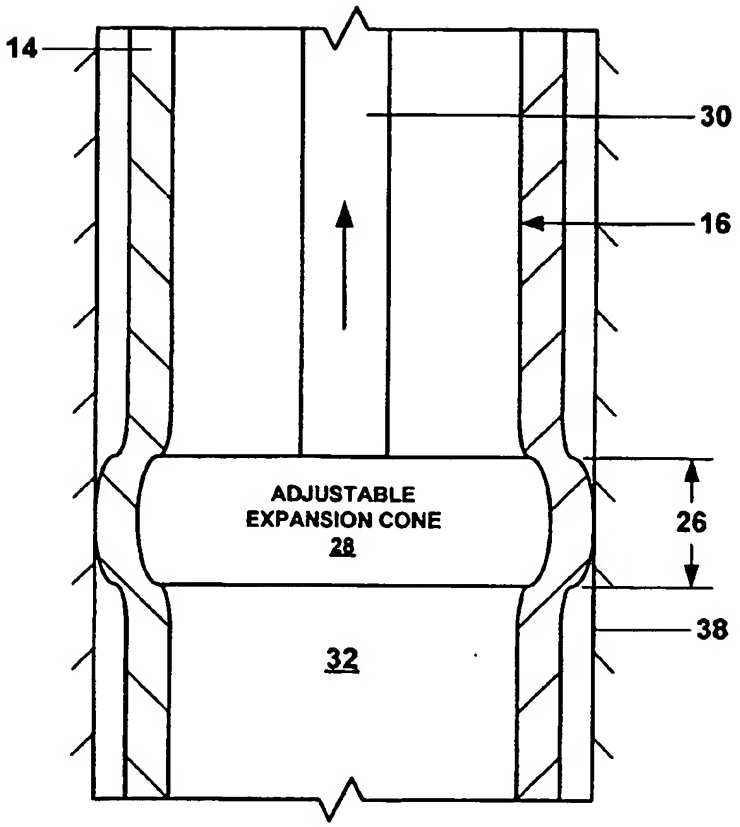

Fig. 2f

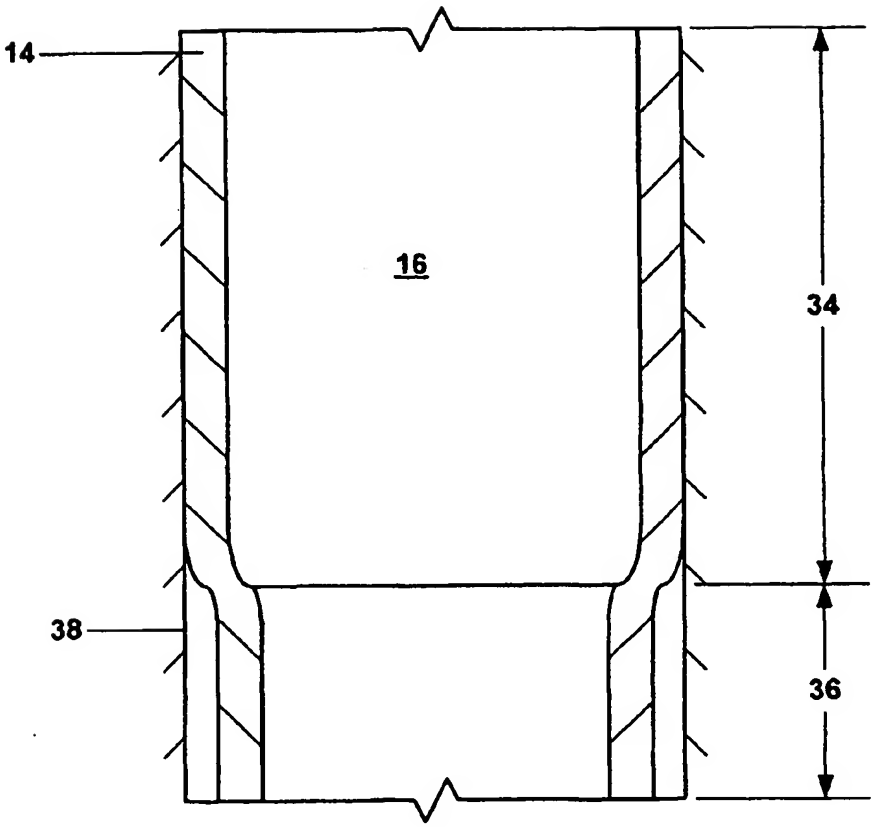

Fig. 2g

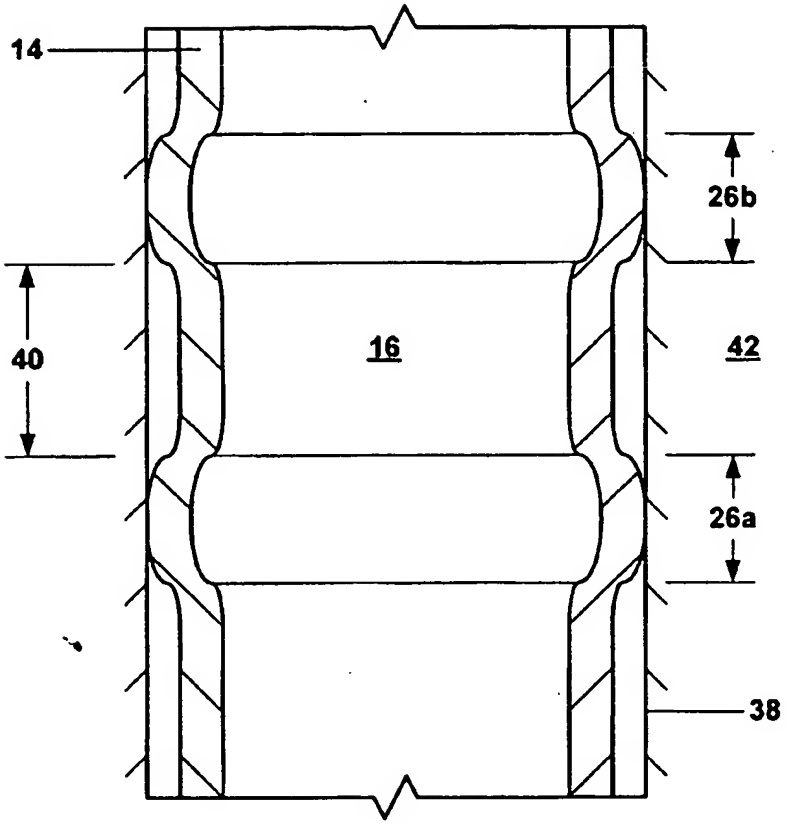

Fig. 3

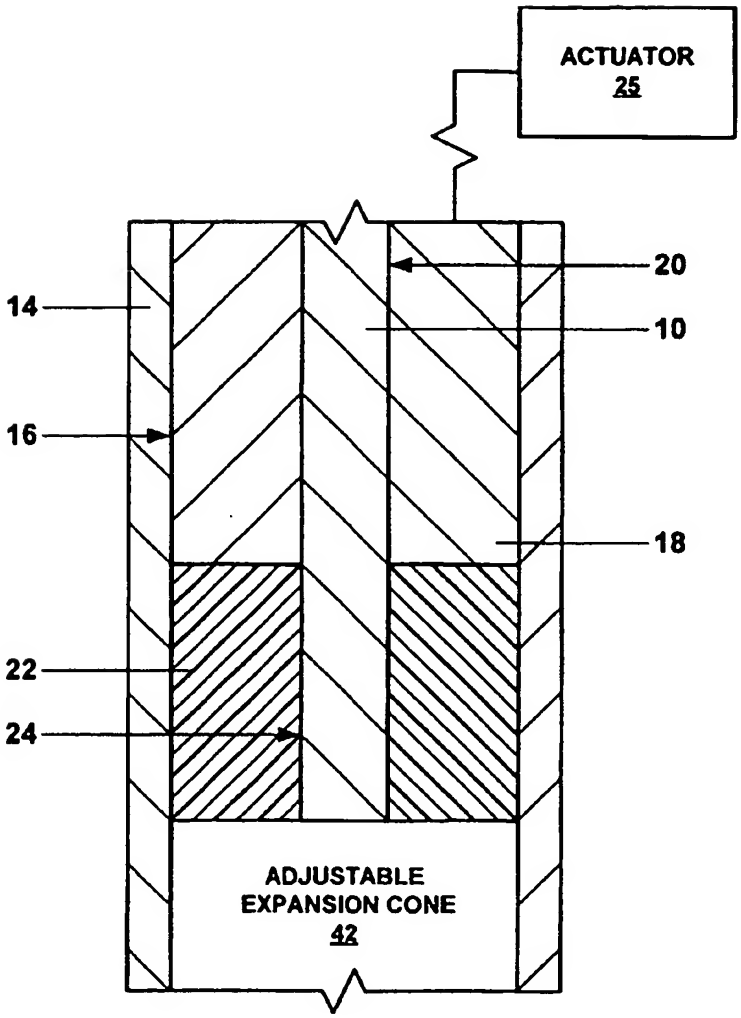

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/11765

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : E21B 43/10
US CL : 166/207,206
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/207,206,217,382; 285/382.4,382.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,871,199 A (Ridenour et al.) 3 October 1989 (03.12.1989), Figure 5, col. 5, lines 46-65.	1-2, 16-18, 20-21, 35-37, 39-40, 42-45
X	US 4,581,817 A (Kelly) 15 April 1986 (15.04.1986), Entire document, Figures 2-3.	1-2, 5, 9-10, 16-18, 20-21, 24, 28-29, 35-37, 39-40, 42-45
X --- Y	US 4,422,317 A (Mueller) 27 December 1983 (27.12.1983), Figures 1-2, col. 1, lines 39-54)	1-2, 4, 16-18, 20-21, 23, 35-37, 39-40, 42-45 --- 5, 10-15, 19, 24, 28-34, 38

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2003 (26.09.2003)	13 NOV 2003
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Lynne H. Browne Telephone No. 703-308-1113

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INTERNATIONAL SEARCH REPORT

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,388,752 A (Vinciguerra et al.) 21 June 1983 (21.06.1983) Entire Document, Figures 1-2.	1-2, 5, 8-10, 16-18, 20-21, 24, 27-29, 35-37, 39-40, 42-45 --- 6-7, 19, 25-26, 38
Y	US 6,6070,671 A (Cumming et al.) 6 June 2000 (06.06.2000), Figures 1 and 4.	5-7, and 24-26
Y	US 3,353,599 A (Swift) 21 November 1967 (21.11.1967) Figures 3-4	12-15, 19, 31-34, 38